CLAIMS

What is claimed is:

1. A method of identifying unknown model parameters of a non-linear dynamic system model having one or more system inputs, comprising:

determining a governing state equation from the system model;

determining a generalized cost function that represents a performance objective for the system;

determining an adjoint equation based at least in part on the governing state equation;

determining a gradient based at least in part on the adjoint equation; and

supplying the governing state equation, the adjoint equation, and the generalized cost function to a processor; and

causing the processor to iteratively determine changes in the generalized cost function that result from incremental changes in arbitrarily chosen values of one or more of the unknown model parameters to thereby identify the unknown model parameters.

2. The method of Claim 1, further comprising:

determining a perturbation state equation based at least in part on the governing state equation; and

determining a perturbation cost function based at least in part on the perturbation state equation and the generalized cost function,

wherein the adjoint equation is determined based at least in part on the perturbation cost function.

3. The method of Claim 1, further comprising:

determining one or more initial states for solving the governing state equation;

supplying one or more of the initial states to the processor; and

causing the processor to iteratively determine changes in the cost function that result from incremental changes in one or more of the initial states.

4. The method of Claim 1, wherein:

the adjoint equation includes one or more adjoint states; and

the incremental changes are driven by gradients derived from the adjoint states.

5. The method of Claim 1, wherein the processor iteratively determines the changes in the cost function until a specified accuracy criterion is met.

6. The method of Claim 1, wherein the processor iteratively determines the changes in the cost function until a predetermined number of iterations is completed.

7. The method of Claim 1, further comprising:

determining the state equation, cost function, adjoint equation, and gradient by supplying one or more exogenous inputs.

8. The method of Claim 1, further comprising:

determining an adjoint identity, wherein the adjoint equation is additionally determined from the governing state equation.

9. The method of Claim 1, further comprising:

validating the non-linear dynamic model using the identified model parameters against one or more sets of experimentally determined data.

10. The method of Claim 1, further comprising:

validating the non-linear dynamic model using the identified model parameters against one or more sets of simulated data.

11. The method of Claim 1, wherein the non-linear dynamic system model includes one or more powertrain system models.

12. A computer-readable medium containing computer executable code that instructs a computer to perform method steps for identifying unknown model parameters of a non-linear dynamic system model having one or more system inputs, the method comprising:

determining a governing state equation from the system model;

determining an adjoint equation based at least in part on the governing state equation;

determining a generalized cost function based on one or more performance objectives for the system;

determining a gradient based at least in part on the determined adjoint equation;

supplying the governing state equation, the adjoint equation, and the generalized cost function to a processor; and

causing the processor to iteratively determine changes in the generalized cost function that result from incremental changes in arbitrarily chosen values of one or more of the unknown model parameters to thereby identify the unknown model parameters.

13. The computer-readable medium of Claim 12, wherein the method further comprises:

determining one or more initial states for solving the governing state equation;

supplying one or more of the initial states to the processor; and

causing the processor to iteratively determine changes in the cost function that result from incremental changes in one or more of the initial states.

14. The computer-readable medium of Claim 12, wherein the method further comprises:

the adjoint equation includes one or more adjoint states; and

the incremental changes are driven by gradients derived from the adjoint states.

15. The computer-readable medium of Claim 12, wherein the processor iteratively determines the changes in the cost function until a specified accuracy criterion is met.

16. The computer-readable medium of Claim 12, wherein the processor iteratively determines the changes in the cost function until a predetermined number of iterations is completed.

17. The computer-readable medium of Claim 12, wherein the method further comprises:

determining the state equation, cost function, adjoint equation, and gradient by supplying one or more exogenous inputs.

18. The computer-readable medium of Claim 12, wherein the method further comprises:

determining an adjoint identity, wherein the adjoint equation is additionally determined from the governing state equation.

19. The computer-readable medium of Claim 12, wherein the method further comprises:

validating the non-linear dynamic model using the identified model parameters against one or more sets of experimentally determined data.

20. The computer-readable medium of Claim 12, wherein the method further comprises:

validating the non-linear dynamic model using the identified model parameters against one or more sets of simulated data.

21. The computer-readable medium of Claim 12, wherein the non-linear dynamic system model includes one or more powertrain system models.

22. A method of identifying unknown model parameters of a non-linear dynamic system model of an automobile powertrain system having one or more system inputs, the method comprising:

determining a governing state equation for the powertrain system from the powertrain system model;

determining a cost function based at least in part on one or more powertrain system performance objectives;

determining a perturbation state equation from the governing state equation for the powertrain system;

determining an adjoint equation from the governing state equation for the powertrain system;

determining a perturbation cost function based at least in part on the determined adjoint equation;

determining a gradient based at least in part on the determined adjoint equation;

supplying the governing state equation, the adjoint equation, and the perturbation cost function to a processor; and

causing the processor to iteratively determine changes in the perturbation cost function that result from incremental changes in arbitrarily chosen values of one or more of the unknown powertrain system model parameters to thereby identify the unknown powertrain system model parameters.

23. The method of Claim 22, further comprising:

determining one or more initial states for solving the governing state equation;

supplying one or more of the initial states to the processor; and

causing the processor to iteratively determine changes in the cost function that result from incremental changes in one or more of the initial states.

24. The method of Claim 22, wherein:

the adjoint equation includes one or more adjoint states; and

the incremental changes are driven by gradients derived from the adjoint states.

25. The method of Claim 22, wherein the changes in the cost function are iteratively determined until a specified accuracy criterion is met.

26. The method of Claim 22, wherein the changes in the cost function are iteratively determined until a predetermined number of iterations is completed.

27. The method of Claim 22, further comprising:

determining the state equation, cost function, adjoint equation, and gradient by supplying one or more exogenous inputs from powertrain system measurements or controller generated signals.

28. The method of Claim 22, further comprising:

determining an adjoint identity, wherein the adjoint equation is additionally determined from the governing state equation.

29. The method of Claim 22, further comprising:

validating the non-linear dynamic model using the identified model parameters against one or more sets of experimentally determined or simulated data.